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Aspect of Minerals in the Hair of Smokers

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흡연자 모발에 함유한 미네랄 함량분석

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요 약

모발은 고통 없이 검체를 채취할 수 있고 저장이 간편하며 인체에 장기간 축적된 미네랄과 중금속함량을 측정하는데 매우 적당한 재료이다. 그러므로 45세 전후의 남자두발을 검체로 하여 상습흡연자(3년 이상 하루 1갑 이상 흡연자)와 비흡연자 그리고 청소년을 대상으로 15종의 영양원소와 8종의 독성원소, 그리고 15종류의 기타원소를 조사 하여 이들 미네랄 함량의 기초 자료를 제시하고자 하였다. 총 38종류의 원소분석은 정확도를 기하기 위하여 Trace elements, Inc (Dallas, Tx, USA)사에 의뢰하였으며, 이곳에서는 유도결합 플라즈마 질량분석기를 사용하여 분석하였다. 결과는 흡연자가 비 흡연자에 비하여 영양원소는 대체적으로 비슷하였으나 특히 Mg($P<0.05$)와 Cu함량이 각각 3.9와 2.4 ppm의 차이로 흡연자가 낮았고, 독성원소는 Hg($P<0.001$)가 0.16과 0.31 ppm으로써 0.15 ppm 차이로 흡연자가 높은 특징을 보였는데, 이것은 최대허용치인 0.18 ppm과 비교해 보았을 때 약 2배 이상 초과 하는 것이 였엇다. 이러한 원인들은 흡연에 있다고 볼 수 있으며, Hg의 중독증상은 중추신경장애와 의욕상실, 만성피로를 일으킬 수 있으며 미나마타병의 원인물질로 알려져 있다. 한편, 청소년과 성인에 있어서 영양원소의 함량은 Cu, P, Mn, B가 각각 3.2, 2.1, 0.016, 0.03 ppm의 차이로 성인에서 높았다. 그러나 생리활성물질인 Ca, Na, K은 각각 58.3, 15.2, 9.0 ppm의 차이로 청소년에서 높았는데, 이것은 성장기 청소년들에게 있어서의 특징이라고 할 수 있다. 독성원소는 Hg가 0.16 ppm으로 성인에서, Cd는 0.01 ppm으로 청소년에서 높았지만 각각 최대 허용치인 0.18과 0.014 ppm 이하였다.

주요어: 모발, 흡연자, 미네랄 함량, 청소년, 독성원소

I. Introduction

Cigarette smoke contains various harmful substances and which may be grouped into granular and gaseous material. Among them, the most distinct substances affecting health are nicotine (C10H14N2), tar, and carbon monoxide. Besides more than twenty kinds of substances including various heavy metals and carcinogens are contained. Meanwhile, absorbed heavy metals are, through blood flow, accumulated in the tissues of each internal organs and some of them are excreted in urine through kidney. Hair is, differently from blood or urine where minerals exist temporarily, appropriate to assess minerals and heavy metals accumulated for a relatively longer period.[1)] In addition, hair can be sampled without pain, is a suitable medium for detection of various kinds of minerals and their temporal changes.[2)]

Among minerals, Mn, Cu, Zn, and Co are called as the four inorganic vitamins. Although they are essential element, they may be harmful at high level and often exerts strong toxicity when it becomes chemical or inorganic form like As.[3)] The largest quantity of Hg is distributed in hair, thus, hair is the most appropriate sample to assess the Hg exposure. Co is stored in liver with vitamin B_{12} together, and it transports and distributed Fe to

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each tissues. S has a close relationship with hair and makes hair strong through formation of S-S bonds in cystine structure; insufficiency of S results in loss of hair, nail cracks, and freckles.[4) Insufficiency of Zn and Fe has been known to cause hair loss, skurf, and skin diseases.[5)]

Studies were carried out in korea also focused on trace elements with use of hair samples. Analysis of six kinds of heavy metals on urban and rural district residents showed large differences by individual: some heavy minerals did not show difference by sex or by age, however contamination with heavy metals is more serious in urban compared to rural district.[6)] Hair analysis of children with mental retardation[7-9)] and recent study on normal male and female children,[10)] which focused on fifteen nutrients and eight toxic elements, showed the differences in the kind of elements between male and female children.

This study was conducted to provide basic data of fifteen nutritional elements, eight toxic elements, and fifteen other elements from the smokers and the nonsmorkers and the young people in Busan district.

II. Material and Methods

Hair samples were collected from 90 person; 28 smorkers, 30 nonsmokers, and 32 young people from July 2003 to October 2003.

The hair samples were collected at two barbershops and one beauty shop (located in representative urban districts in Busan) after intensive training of sample collectors. Smokers were defined as the ones who smorke more than one pack of cigarettes a day for more than three years. Persons under routine medication were excluded from the subject for hair sampling. Only virgin hair samples (no-perm and non-dyeing) were collected from the young and adult people. Most of hair samples were collected on the occipital area of scalp heads, and quantity of each sample was 200 mg or more. Samples were stored at room temperature untill the chemical analysis.

Mean ages of smokers, nonsmokers, and young people were 45.8±4.8, 45.2±4.9, and 16.2±4.8, respectively.

Minerals were analyzed using Coupled Plasma Mass Spectrometry (Sciex elan 6100, Perkin-Elmer corporation, Foster, CA, USA) at Trace Elements, Inc. (Dallas, TX, USA).

Minerals under investigation were a total of 38 elements; including 15 nutritional elements such as, Calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), copper (Cu), zinc (Zn), phosphorous (P), iron (Fe), manganese (Mn), chromium (Cr), selenium (Se), boron (B), cobalt (Co), molybdenum (Mo), and sulfur (S); 8 toxic elements, such as antimony (Sb), uranium (U), arsenic (As), beryllium (Be), mercury (Hg), cadmium (Cb), lead (Pb), and aluminum (Al); and 15 other elements, such as germanium (Ge), barium (Ba), bismuth (Bi), rubidium (Rb), lithium (Li), nickel l(Ni), platinum (Pt), thallium (Ti), vanadium (V), strontium (Sr), tin (Sn), titanium (Ti), tungsten (W), and zirconium (Zr).

Statistical analysis was carried out with SPSS-PC program.

III. Result

1. Comparison of mineral contents in the hair of smokers and nonsmokers

Analytical results of nutritional elements, toxic elements, and other elements are summarized in Table 1.

Most of fifteen nutritional elements showed similar contents in smokers and nonsmokers, but Mg ($p<0.05$) and Cu were lower in smokers than in nonsmokers. With hair samples of smokers, Mg and Ca were relatively lower ar 3.9 and 2.4 ppm, respectively. With nonsmoker, Mn and Co levels were 2.1, and 2.3 ppm, respectively, which were relatively higher than those from the smokers.

Among five toxic elements, especially, Hg ($p<0.001$) showed high accumulation in smokers (0.3 ppm) in comparison to nonsmokers (0.19 ppm). This level is almost two times reference value, 0.09 ppm. High levels Hg exposure may show the symptoms associated with central nerve and muscular systems.

Acute toxication of Hg causes the symptoms of insomnia, arthritis, anxiety and impatience, anorexia, and rage reaction. It is also related with chronic fatigue, and autism.

Although other eleven elements showed similar

Table 1. A Comparison between nonsmoker and smoker on the nutritional, toxic, additional elements of hair mineral contents

Sort (N.E)[e]		N[c]	Mean ± SD[d]	Sort (T.E)[f]		N	Mean ± SD	Sort (A.E)[g]		N	Mean ± SD
Ca	1[a]	30	137.1 ± 55.8	As	1	30	$1.0\times10^{-2}\pm3.6\times10^{-3}$	Ge	1	30	$5.1\times10^{-3}\pm1.0\times10^{-3}$
	2[b]	28	126.1 ± 64.0		2	28	$1.0\times10^{-2}\pm3.8\times10^{-3}$		2	28	$6.1\times10^{-3}\pm1.0\times10^{-3}$
Mg	1	30	14.3 ± 7.5	Hg	1	30	$0.1\pm9.3\times10^{-2}$	Ba	1	30	0.2 ± 0.1
	2	28	10.4 ± 7.2*		2	28	$0.3\pm0.3\times10^{-2}$***		2	28	0.2 ± 0.1
Na	1	30	44.3 ± 44.1	Cd	1	30	$2.6\times10^{-3}\pm5.1\times10^{-4}$	Bi	1	30	$1.6\times10^{-3}\pm7.6\times10^{-4}$
	2	28	44.4 ± 11.2		2	28	$7.5\times10^{-3}\pm5.6\times10^{-3}$		2	28	$2.0\times10^{-3}\pm0.0$
K	1	30	25.3 ± 22.0	Pb	1	30	0.1 ± 0.1	Rb	1	30	$2.3\times10^{-2}\pm2.1\times10^{-2}$
	2	28	20.7 ± 8.3		2	28	$1.1\pm7.4\times10^{-2}$		2	28	$2.1\times10^{-2}\pm9.8\times10^{-3}$
Cu	1	30	4.3 ± 6.7	Ai	1	30	0.5 ± 0.4	Li	1	30	$8.8\times10^{-3}\pm2.6\times10^{-3}$
	2	28	1.9 ± 1.1		2	28	0.3 ± 0.1		2	28	$1.2\times10^{-3}\pm4.6\times10^{-4}$
Zn	1	30	16.8 ± 2.3					Ni	1	30	$7.3\times10^{-2}\pm3.7\times10^{-2}$
	2	28	16.8 ± 1.9						2	28	0.1 ± 0.1
P	1	30	15.3 ± 2.4					V	1	30	$6.3\times10^{-3}\pm3.0\times10^{-3}$
	2	28	16.1 ± 3.0						2	28	$4.7\times10^{-3}\pm1.1\times10^{-3}$
Fe	1	30	1.0 ± 0.3					Sr	1	30	0.8 ± 0.5
	2	28	1.0 ± 0.3						2	28	0.8 ± 0.5
Mn	1	30	$5.9\times10^{-2}\pm4.7\times10^{-2}$					Sn	1	30	$2.1\times10^{-2}\pm1.3\times10^{-2}$
	2	28	$8.0\times10^{-2}\pm3.8\times10^{-2}$						2	28	$2.1\times10^{-2}\pm1.4\times10^{-2}$
Cr	1	30	$5.0\times10^{-2}\pm1.1\times10^{-2}$					Ti	1	30	$5.3\times10^{-2}\pm7.5\times10^{-3}$
	2	28	$5.1\times10^{-2}\pm1.3\times10^{-2}$						2	28	0.1 ± 0.2
Se	1	30	$7.5\times10^{-2}\pm1.4\times10^{-2}$					Zr	1	30	$1.1\times10^{-2}\pm3.7\times10^{-3}$
	2	28	$7.5\times10^{-2}\pm1.7\times10^{-2}$						2	28	$1.0\times10^{-2}\pm0.0$
B	1	30	0.1 ± 0.3								
	2	28	$9.4\times10^{-2}\pm6.2\times10^{-2}$								
Co	1	30	$2.0\times10^{-3}\pm8.3\times10^{-3}$								
	2	28	$4.3\times10^{-3}\pm6.5\times10^{-3}$								
Mo	1	30	$3.6\times10^{-3}\pm1.3\times10^{-3}$								
	2	28	$3.7\times10^{-3}\pm1.7\times10^{-3}$								
S	1	30	4236.3 ± 271.7								
	2	28	4165.0 ± 210.4								

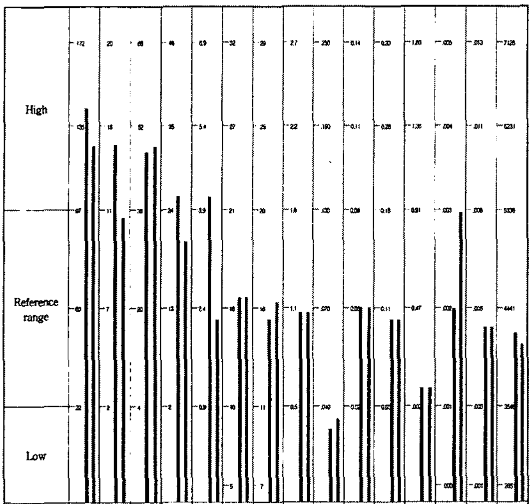
a. None-smoker group. b. Smoker group. c. Number. d. Values, e. Nutritional elements. f. Toxic elements. g. Additional Elements.

*Sig. (T-Test) *<0.05 **<0.01 ***<0.001.

levels between nonsmoker and smoker groups, Ni and Ti had high levels as 0.12 ppm each. Ni is related to biosynthesis of protein. In case of Ni deficiency, symptoms such as myocardial infarction, liver disease, and diabetes may occur. When exposured excess amount of NI, symptoms such as lung cancer and pneumonia may occur.[3] Ti has been known to have nutritional value in activation of metabolism, blood production, prevention of bleeding, and treatment of neuralgia. Reference ranges of Ni and Ti are 0.05 ppm and 0.10 ppm, respectively.

For easy comparison of this result, bar graphs were shown in Figs. 1-3 nutrients, toxic elements, and other elements.

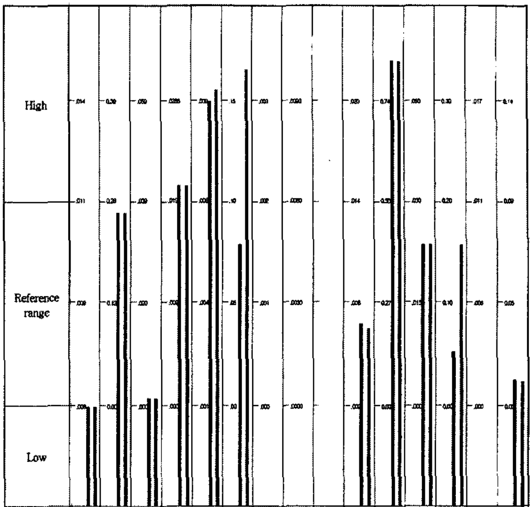
In case of nutritional elements, both smokers and nonsmokers showed higher levels of Ca (137.2 ppm) and Na (126.1 ppm) in comparison to reference ranges, i.e., 60 ppm and 20 ppm, respectively. This result was considered to be caused by geographical characteristic of Busan that is located near to the sea, where various seafood and the related such as seaweeds, fishes, and salt are available. Similar result was found in young people



Sort (N.E)[3]	Ca	Mg	Na	K	Cu	Zn	P	Fe	Mn	Cr	Se	B	Co	Mo	S
1 (Mean/PPM)	137.2	14.3	44.3	25.3	4.3	16.8	15.3	1.0	0.06	0.05	0.08	0.09	0.002	0.004	4236
2 (Mean/PPM)	126.1	10.5	44.4	20.7	1.9	16.8	16.1	1.0	0.08	0.05	0.08	0.09	0.003	0.004	4165

1. None-smoker 2. Smoker 3. Nutritional elements.

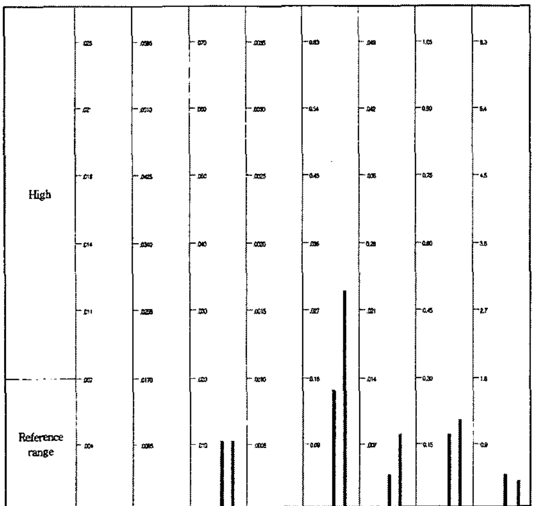
Fig. 1. A comparison between none-smoker and smoker on the nutritional elements of hair mineral contents.



Sort (N.E)[3]	Ge	Ba	Bi	Rb	Li	Ni	Pt	Ti	I	V	Sr	Sn	Ti	W	Zr
1 (Mean/PPM)	0.005	0.21	0.002	0.02	0.009	0.07	<	<	N/A	0.006	0.89	0.02	0.05	<	0.01
2 (Mean/PPM)	0.006	0.21	0.002	0.02	0.012	0.19	<	<	N/A	0.005	0.89	0.02	0.17	<	0.01

1. None-smoker 2. Smoker 3. additional elements. < is below calibration limit.

Fig. 3. A comparison between none-smoker and smoker on the additional elements of hair mineral contents.



Sort (N.E)[3]	Sb	U	As	Be	Hg	Cd	Pb	Al
1 (Mean/PPM)	N/A	<	0.01	<	0.16	0.0026	0.18	0.50
2 (Mean/PPM)	N/A	<	0.01	<	0.31	0.008	0.16	0.31

1. None smoker 2. Smoker 3. Toxic elements. N/A is Currently not available < is below calibration limit.

Fig. 2. A comparison between none-smoker and smoker on the toxic elements of hair mineral contents.

as well.

Mg, K, and Cu contents in nonsmokers were 14.4, 25.3, and 4.3 ppm. respectively, which were higher than the reference ranges, i.e., 7, 13, and 2.4 ppm, respectively.

In case of toxic elements, Hg contents was 0.31 ppm in smokers which exceeds reference value, i.e., 0.09 by more than two times. The contents of other elements were within the reference ranges.

In case of other elements, Rb, Li, and Sr contents exceeded reference ranges in both the control group and smoker group. Contents of Ni was 0,19 ppm in smoker group which was higher than that of control group, 0.07 ppm, and exceeded reference value of 0.05 ppm.

2. Comparative analysis of mineral contents in hair of the young and the adult

Mineral contents in hair of the young and the adult are summarized in Table 2.

Most of nutritional elements were similar in young people and adults, however, the contents of four elements which were Cu, P, Mn, and B, were

Table 2. A Comparison of the nutritional, toxic, additional elements of hair mineral contents between the young and the adults

Sort (N.E)[e]		N[c]	Mean±SD[d]	Sort (T.E)[f]		N	Mean±SD	Sort (A.E)[g]		N	Mean±SD
Ca	1[a]	32	195.5±238.7	As	1	32	$9.0\times10^{-3}\pm4.2\times10^{-3}$	Ge	1	32	$7.5\times10^{-3}\pm1.5\times10^{-3}$
	2[b]	30	137.1±55.8		2	30	$1.0\times10^{-2}\pm3.6\times10^{-3}$		2	30	$5.4\times10^{-3}\pm1.0\times10^{-4}$
Mg	1	32	14.9±15.9	Hg	1	32	$7.7\times10^{-2}\pm5.9\times10^{-2}$	Ba	1	32	0.3±0.4
	2	30	14.3±7.5		2	30	$0.1\pm9.3\times10^{-2}$		2	30	0.2±0.1
Na	1	32	59.5±50.7	Cd	1	32	$1.4\times10^{-2}\pm1.8\times10^{-2}$	Bi	1	32	$4.0\times10^{-3}\pm3.5\times10^{-3}$
	2	30	44.3±44.1		2	30	$3.1\times10^{-2}\pm4.5\times10^{-2}$*		2	30	$1.6\times10^{-3}\pm7.6\times10^{-4}$
K	1	32	34.2±27.6	Pb	1	32	$0.2\pm4.3\times10^{-2}$	Rb	1	32	0.1±0.2
	2	30	25.3±22.0		2	30	0.1±0.1		2	30	$2.3\times10^{-2}\pm2.1\times10^{-2}$
Cu	1	32	1.1±0.1	Ai	1	32	0.4±0.2	Li	1	32	$1.2\times10^{-3}\pm4.9\times10^{-4}$
	2	30	4.3±6.7**		2	30	0.5±0.4		2	30	$8.8\times10^{-3}\pm2.6\times10^{-3}$
Zn	1	32	13.5±1.8					Ni	1	32	0.1±0.1
	2	30	16.8±2.3						2	30	$7.3\times10^{-2}\pm3.7\times10^{-2}$
P	1	32	13.2±2.9					V	1	32	$6.0\times10^{-3}\pm2.5\times10^{-3}$
	2	30	15.3±2.4**						2	30	$6.3\times10^{-3}\pm3.0\times10^{-3}$
Fe	1	32	1.3±0.7					Sr	1	32	1.0±1.2
	2	30	1.0±0.3*						2	30	0.8±0.5
Mn	1	32	$4.3\times10^{-2}\pm2.0\times10^{-2}$					Sn	1	32	$2.7\times10^{-2}\pm2.0\times10^{-2}$
	2	30	$5.9\times10^{-2}\pm4\times10^{-2}$*						2	30	$2.1\times10^{-2}\pm1.3\times10^{-2}$
Cr	1	32	$5.0\times10^{-2}\pm7.1\times10^{-2}$					Ti	1	32	$7.2\times10^{-2}\pm1.1\times10^{-2}$
	2	30	$5.0\times10^{-2}\pm1.1\times10^{-2}$						2	30	$5.3\times10^{-2}\pm7.5\times10^{-3}$
Se	1	32	$5.0\times10^{-2}\pm1.1\times10^{-2}$					Zr	1	32	$1.0\times10^{-2}\pm0.0$
	2	30	$7.5\times10^{-2}\pm1.4\times10^{-2}$						2	30	$1.1\times10^{-2}\pm3.7\times10^{-4}$
B	1	32	$7.0\times10^{-2}\pm5.1\times10^{-2}$								
	2	30	0.1±0.3*								
Co	1	32	$2.0\times10^{-3}\pm1.2\times10^{-3}$								
	2	30	$2.0\times10^{-3}\pm8.3\times10^{-4}$								
Mo	1	32	$5.2\times10^{-3}\pm8.4\times10^{-4}$								
	2	30	$3.6\times10^{-3}\pm1.3\times10^{-3}$								
S	1	32	3945.0±212.5								
	2	30	4236.3±271.7								

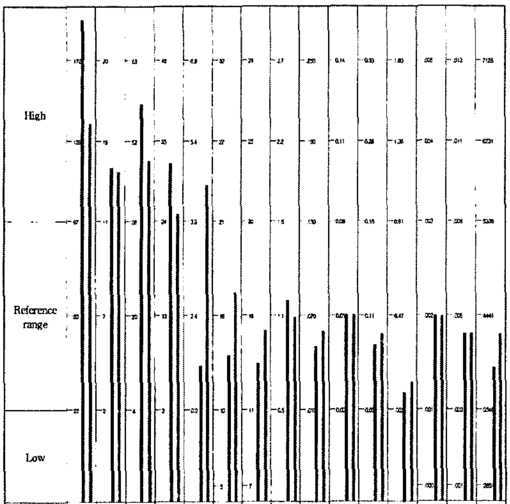
a. Young group. b. Adults group. c. Number. d. Values, e. Nutritional elements. f. Toxic elements. g. Additional elements.
*Significance level (t-Test) *<0.05 **<0.01.

significantly higher in adult ($p<0.05$). On the other hand, Fe content was significantly higher in the young ($p<0.05$). Fe deficiency is known to cause anemia and its incidence is known to be higher in men than in women.

Among toxic elements, Hg was higher in adults (0.16 ppm), and also Cd was slightly higher in young people (0.01 ppm).

With additional elements, Bi and Rb were higher in young people with difference by 0.0024 ppm and 0.077 ppm than those of adults. Ni content was higher in adults with difference by 0.027 ppm than those of young people. However, there were no statistical significances ($p>0.05$). For convenient comparison, bar graph are presented in Figs. 4-6 for nutritional elements, toxic elements, and other elements, respectively.

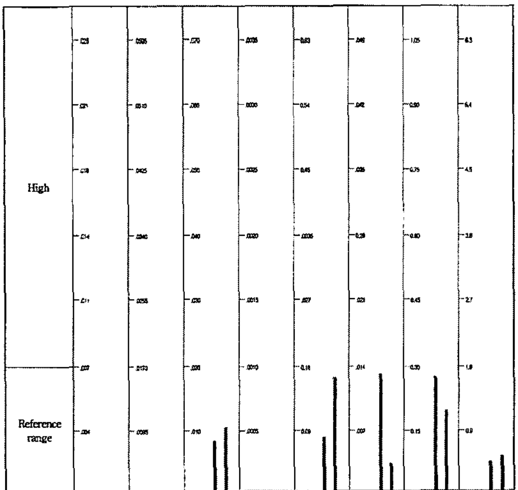
Among nutritional elements, Ca contents were 195.5, and 137.2 ppm in the young and the adults, respectively. For the young, and the adults, Mg was detected at 14.9 and 14.3 ppm, Na, 59.5 and 44.3 ppm, and K, 34.3, and 25.3 ppm, respectively. These values were in excess of the reference values for the young and the adult: Ca exceeded the



Sort (N.E)[3]	Ca	Mg	Na	K	Cu	Zn	P	Fe	Mn	Cr	Se	B	Co	Mo	S
1 (Mean/PPM)	195.5	14.9	59.5	34.3	1.15	13.5	13.2	1.3	0.04	0.05	0.05	0.07	0.002	0.005	3945
2 (Mean/PPM)	137.2	14.3	44.3	25.3	4.3	16.8	15.3	1.0	0.06	0.05	0.08	0.19	0.002	0.004	4236

1. Juveniles group. 2. Adults group. 3. Nutritional elements.

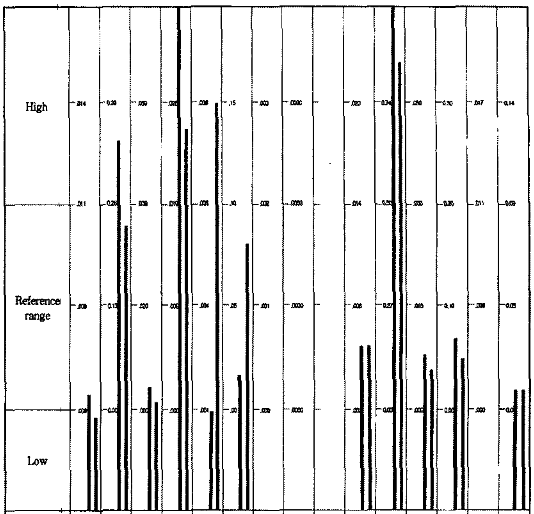
Fig. 4. A comparison between juveniles group and adults group on the nutritinal elements of hair mineral contents.



Sort (N.E)[3]	Sb	U	As	Be	Hg	Cd	Pb	Al
1 (Mean/PPM)	N/A	<	[illegible]	<	0.08	0.01	0.27	0.47
2 (Mean/PPM)	N/A	<	0.01	<	0.16	0.0026	0.18	0.50

1. Juveniles group 2. Adults group 3. Toxic elements. N/A is Currently not available < is below calibration limit.

Fig. 5. A comparison between juveniles group and adults group on the toxic elements of hair mineral contents.



Sort (N.E)[3]	Ge	Ba	Bi	Rb	Li	Ni	Pt	Ti	I	V	Sr	Sn	Ti	W	Zr
1 (Mean/PPM)	0.008	0.35	0.004	0.15	0.001	0.001	<	<	N/A	0.006	1.03	0.03	0.07	<	0.01
2 (Mean/PPM)	0.005	0.21	0.002	0.02	0.009	0.008	<	<	N/A	0.006	0.89	0.02	0.05	<	0.01

1. Juveniles group 2. Adults group 3. Additional elements. < is below calibration limit.

Fig. 6. A comparison between juveniles group and adults group on the additional elements of hair mineral contents.

reference value by 135.5 in the young, and by 77.2 ppm in adults: Mg exceeded the reference values by 7.9 and by 7.3 ppm in adults and Na exceeded the reference value by 39.5 in the young, and by 24.3 ppm in adults: K exceeded by 21.3 in the young, and by 12.3 in adults. The reference values for Ca, Mg, Na, and K are 60, ppm 7, 20, and 13, respectively.

Content of Cu was 4.3 ppm in adults and notably exceeded reference range. Other nutrients showed similar levels to reference ranges.

In case of toxic elements, the mean Hg content in adults was 0.16 ppm, which was higher than 0.08 ppm of the young. Although Cd content was higher in young people, it was still within the reference range.

Among other elements, contents of Rb in the young and the adults were 0.02 and 0.15 ppm, with Sr, 0.89 and 1.03 ppm, respectively. The levels all exceeded reference ranges of Rb and Sr, i.e., 0.27, and 0.009 ppm. Remaining other elements showed similar levels between the young and the adults.

IV. Discussion

Hair is consisted of three-fold cuticle layer (epicuticle, exocuticle, and endocuticle), cortex part, and medulla part, and the largest portion is cortex part. In terms of constituents of hair, 80-85% is keratin that is a protein for structure, and remaining is 10-15% of water, 1-8% of lipid, 1-3% of pigment and 0.8-1% of micro substances.[4)]

Life cycle of hair consisted of anagen (3-4 years), catagen (1-3 months), and telogen (2-3 months). The hair growth rate is approximately 1 cm a month in general, and is becoming higher in May and June. It is known that 50 to 100 per 100,000 hairs were lost during a day in telogen.[4)]

Many investigator's opinions were differenced whether contents of heavy metals shall be reflected from those of body or not.[11-13)]

For example, Kruse-Jarres and his co-workers indicated that the variation in contents of heavy metals was influenced by the kind of hair, season, growth rate, and method of analysis. Thus, our results were obtained by Induction Coupled Plasmamass Spectrometry (in TEI TX, USA). Hg among toxic elements, and Mn and Co of nutritional elements were occurred more high ratio in smoker than those of nonsmoker.

Meanwhile, at least twenty kinds of carcinogenic substances are contained in cigarettes. Deaths caused by diseases related to cigarettes are estimated to be about four million in the world a year. This number is larger than the sum of deaths caused by AIDS, tuberculosis, traffic accidents, suicide, and strife massacrer. Symptoms after reduction or quitting of nicotine are displeasure and depression at the first stage, insomnia, grumbles, and frustration at the second stage, and anxiety, decreased attention, restless, and reduced heart rate follow as the third stage. As oral cavity is acidic (pH 5.5) during smoking, most of nicotine is ionized and is rarely absorbed in the mucous membrane of oral cavity. However the surface area of pulmonary bubble is large, and blood supply is increased in lung and thus nicotine is rapidly absorbed into lung. Chewing tobacco, snuff, and chewing nicotine gum are also actively absorbed into mucose membrane.

Absorbed nicotine was arrived at brain in 7-19 minutes, and then nicotine receptors are desensitized and increased their density of nicotine. Pharmacological property of nicotine was known to be important in establishment of dependence in central nervous system.[14)]

In other facts, Rushton and co-workers[5)] demonstrated that lose hair is prevented by supplying with Fe and L-lysine in telogen phase.

In this study, High levels of Fe, Ca, Na, and K in young people were considered due to involvement in prosperous growth of young people than to slow or stopped growth in adults results in low levels of them. Thus, the reason that bold heads were not found in young people but adults were involved in nutritional factors except hereditary factor. Apart from expectation, in the respect of toxic elements, there was no significant difference between smokers and nonsmokers, except Hg.

Particularly, Cd content was higher in nonsmokers (0.45 ppm) in comparison to smokers (0.008 ppm), which is still higher than reference range, 0.14 ppm (this was excluded from study data). This was considered to be related to their job. Because sampling was made in random method, the five nonsmoking samples with significantly high Cd contents were traced and found that most of them have been working in a chemical factory producing acrylic products. This result means that toxic elements show significant differences by job. Although Cd toxication causes disturbance in kidney function and calcium metabolism that results in osteomalacia, and Itai-Itai disease, there was no apparent finding of these diseases from the donors of hair sample.

The assay method to use hair sample has been utilized for a long time for limited purposes such as diagnosis of medication toxication or heavy metallic exposure.[15)] Also, unbalanced mineral contents and accumulation of toxic elements in the body had been known to cause various diseases. Cr deficiency is related to juvenile diabetes; excess in Cu and Zn contents causes atopic dermatitis and vitiligo;[16)] abnormal Se content causes alopecia areata: abnormal Zn content causes acne.[17-19)] Abnormal Hg content causes central nervous system disturbance and Minamata disease.

In this study, the reason of significantly higher Hg content in smokers compared to reference range was considered to be smoking.

Meanwhile, it was reported that when mineral contents were assayed comparison of hair samples and blood samples of young people, content of Cu was higher by 10 times, contents of As and Cd etc were higher by 100 times, contents of Co etc were higher by 1,000 times, contents of Cr etc were higher by 10,000 times.[10)]

It suggests that the low amounts of minerals in hairs are needed for long-term accumulation although most minerals were high amounts found in blood than in hairs.

Therefore, further study is required for utilization as basic data through accumulation of long-term data with distinguishing by job, aging group and territory.

V. Conclusion

Hair is a very suitable material to measure the contents of minerals and heavy metals accumulated for a long time. This study was conducted to obtain basic data of 15 nutritional elements, 8 toxic elements, and 15 other elements levels in hair from the smokers and the nonsmokers and the young people in Busan district.

The results of this study showed that contents of nutritional elements were similar in smokers and nonsmokers, but Mg (3.9 ppm, $p<0.05$) and Cu (2.4 ppm) contents showed lower levels than nonsmokers.

In case of toxic elements, Hg level was especially high in smokers (0.3 ppm, $p<0.001$) in comparison to that of nonsmokers (0.16 ppm). When mineral levels in hair compared between the young and adult, the nutritional elements, such as Ca (58.3 ppm), Na(15.2 ppm), K(9.0 ppm), Fe(0.3 ppm) contents were higher in the young than the adults, which may be due to the rapid growth of young people's hair comparing to the adults group.

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